ornamentation. One (rarely 2) secondary riblets sometimes in interspaces.

Discussion: Although a protoconch appears to be present in the lowermost individual of the holotype, LACMIP 8091 (Figure 9), the dome-shaped structure is only the result of weathering in the apical area.

?*Serpulorbis* ***llajasensis*** is similar to *S. polygonus* Deshayes (1861:285, pl. 9, fig. 14; Cossmann & Pissarro, 1910–1913:pl. 22, fig. 131-12) from lower through upper Eocene (Ypresian Stage through Bartonian Stage) strata in Paris Basin, France. A comparison between ?*S.* ***llajasensis*** and eight UCMP Cloez collection specimens of *S. polygonus* from Crenes, Oise, Paris Basin, revealed that ?*S.* ***llajasensis*** differs in the following feature: cancellate ornamentation is much more developed because the collabral costae and spiral ribs are nearly equal rather than having weaker collabral costae.

Whether or not the new species possesses an operculum is not known, and thus a definite generic assignment cannot be made. The new species is questionably assigned to ?*Serpulorbis* because the geologic range of this genus, unlike *Vermetus,* encompasses the middle Eocene age of the new species. ?*Serpulorbis* is known from lower Paleocene, upper Paleocene, and upper Eocene strata in the eastern United States (Gardner, 1933; Palmer & Brann, 1966; Toulmin, 1977), but previously the genus has not been reported from the Paleogene of the Pacific coast of North America. It is only known from the Pleistocene to Recent in this particular area (Grant & Gale, 1931; Keen, 1961). The new species is not like any of the other fossil or Recent *Serpulorbis* from North America. The new species is also not like any fossil or Recent *Vermetus* from North America. ?*Serpulorbis* ***llajasensis*** is the earliest occurrence of a vermetid from the Pacific coast of North America.

Etymology: The specific name is for the Llajas Formation.

Material: Five specimens, three of which are intergrown. The other two are solitary forms.

Occurrence: Middle Eocene Lutetian Stage. Middle Llajas Formation, northern Simi Valley, southern California, locality UCLA 2312.

Repository: Holotype, LACMIP 8091, and paratype, LACMIP 8092; locality UCLA 2312.

ACKNOWLEDGMENTS

R. S. Vernis (Departamento de Geología, Universidad Autónoma de Baja California Sur, La Paz) kindly arranged for permission for paleontologic collecting in Baja. M. C. Perrilliat (Instituto de Geología, Universidad Nacional Autónoma Museum de México) graciously provided type-specimen numbers for the Baja specimens.

J. Alderson, R. Demetrion, L. T. Groves (Natural History Museum of Los Angeles County), and M. Saenz (California University, Northridge, Department of Geological Sciences) helped in collecting specimens. J. Le Renard (National Institute of Agronomical Research, Versailles, France) guided me to the Villiers-St.-Frederic collecting area.

G. L. Kennedy (Natural History Museum of Los Angeles County) provided access to collections and provided for the loan of specimens. D. R. Lindberg (University of California, Berkeley) provided for the loan of specimens from the Cloez collection.

R. Bieler (Delaware Museum of Natural History) gave important insights on taxonomy and L. R. Saul (Natural History Museum of Los Angeles County) gave important comments on identification. L. T. Groves provided some key references.

Helpful comments on the manuscript were made by two anonymous reviewers.

LITERATURE CITED

Anton, H. E. 1838. Verzeichniss der Conchylien welche sich in der Sammlung von Herrmann Eduard Anton befinden. Privately published: Halle. 110 pp.

Bottjer, D. J. & D. Jablonski. 1988. Paleoenvironmental patterns in the evolution of post-Paleozoic benthic marine invertebrates. Palaios 3:540–560.

Bruguière, J. G. 1789–1816. Encyclopédie méthodique ou par ordre et matieres. Histoire naturelle des vers, des mollusques. Pancoucke: Paris. 758 pp., Atlas, 488 pp.

Cossmann, M. 1912. Essais de paléoconchologie compareé. Vol. 9. Privately published: Paris. 215 pp.

Cossmann, M. & G. Pissarro. 1910–1913. Iconographie completé des coquilles fossiles de l'Éocène des environs de Paris. Vol. 2. H. Bouillant: Paris. 65 pls.

Daudin, F. M. 1800. Recueil de mémoires et de notes sur les especes inedites ou peu connues de mollusques, de vers et de zoophytes. Paris. 50 pp.

Davies, A. M. 1971. Tertiary faunas—a text-book for oilfield palaeontologists and students of geology. Vol. 1. The composition of Tertiary faunas. Revised and updated by F. E. Eames. George Allen and Unwin: London. 571 pp.

Defrance, M. J. L. 1804–1845. Dictionnaire universel des sciences naturelles. Paris.

Deshayes, G. P. 1856–1866. Description des animaux sans vertebres découverts dans bassin de Paris. 3 Vols. J.-B. Bailliere et fils: Paris. 2536 pp., Atlas, 101 pls.

Filewicz, M. V. & M. E. Hill, III. 1983. Calcareous nannofossil biostratigraphy of the Santa Susana and Llajas Formations, northern Simi Valley. Pp. 45–60. *In:* R. L. Squires & M. V. Filewicz (eds.), Cenozoic geology of the Simi Valley area, southern California. Pacific Sec., Soc. Econ. Paleontol. & Mineral.: Los Angeles, California.

Fleming, J. 1822. The philosophy of zoology; or a general view of the structure, functions and classification of animals. 2 Vols. Edinburgh. 1050 pp.

Gabb, W. M. 1864. Description of the Cretaceous fossils. California Geol. Surv., Palaeontology 1:57–243.

Gardner, J. 1933. The Midway Group of Texas. Univ. Texas Bull. 3301, 403 pp.

Glibert, M. 1933. Monographie de la faune malacologique du Bruxellien des environs de Bruxelles. Mem. Musée Roy. d'Hist. Nat. Belgique, sér. 1, 53:1–208.

Gould, S. J. 1966. Notes on shell morphology and classification

of the Siliquariidae (Gastropoda): the protoconch and slit of *Siliquaria squamata* Blainville. Amer. Mus. Novitates No. 2263, 13 pp.

Grant, U. S., IV & H. R. Gale. 1931. Catalogue of the marine Pliocene and Pleistocene Mollusca of California and adjacent regions. Mem. San Diego Soc. Natur. Hist. 1:1–1036.

Guettard, J. E. 1770. Qui referme la concordance des quteurs qui ont parlé des tuyaux marins fossiles, auxquels on a comparé ceux qui se pêchent actuellement dans la mer (2. Mém.). Mém. differentes parties des Sci. et Arts 3:18–129.

Healy, J. M. 1988. Sperm morphology in *Serpulorbis* and *Dendropoma* and its relevance to the systematic position of the Vermetidae (Gastropoda). Jour. Moll. Stud. 54:295–308.

Heitman, H. L. 1983. Paleoecological analysis and biostratigraphy of the lower Paleogene Santa Susana Formation, northern Simi Valley, Ventura County. Pp. 33–44. *In:* R. L. Squires & M. V. Filewicz (eds.), Cenozoic geology of the Simi Valley area, southern California. Pacific Sec., Soc. Econ. Paleontol. & Mineral.: Los Angeles, California.

Keen, A. M. 1961. A proposed reclassification of the gastropod family Vermetidae. Bull. Brit. Mus. (Natur. Hist.) Zoology 7:183–212.

Linné, C. 1758. Systema naturae per regna tria naturae. Editio 10, reformata 1(1):1–824. Salvii: Holmiae.

Morton, J. E. 1951. The structure and adaptations of the New Zealand Vermetidae. Pt. 1. The genera *Stephopoma* and *Pyxipoma*. Trans. Proc. Roy. Soc. New Zealand 79:20–42.

Morton, J. E. 1955. The evolution of vermetid gastropods. Pacific Sci. 9:3–15.

Palmer, K. V. W. & D. C. Brann. 1965–1966. Catalogue of the Paleocene and Eocene Mollusca of the southern and eastern United States. Bull. Amer. Paleontol. 48:1–1057.

Parker, J. D. 1983. Lower Paleocene to lower Eocene, nonmarine to deep-marine strata of the Simi Hills, Ventura County, California. Pp. 3–22. *In:* R. L. Squires & M. V. Filewicz (eds.), Cenozoic geology of the Simi Valley area, southern California. Pacific Sec., Soc. Econ. Paleontol. & Mineral.: Los Angeles, California.

Rafinesque, C. S. 1815. Analyse de la nature, ou tablesau de l'universe et des corps organisées. Palermo. 224 pp.

Sacco, F. 1896. I molluschi dei terreni Terziari del Piemonte e della Liguria. Mus. Zool. Anat. Comp. R. Univ. Torino Boll. 20:1–65.

Sassi, A. 1827. Saggio geologico sopra il Bacino Terziario di Albenga. Giorn. Ligust. Sci. Lett. Arti Genova 1:467–484.

Saul, L. R. 1983. *Turritella* zonation across the Cretaceous-Tertiary boundary, California. Univ. Calif. Publ. Geol. Sci. 125:1–165.

Smith, J. T. 1986. Middle Tertiary rocky substrate mollusks from Baja California Sur, Mexico. Amer. Malacol. Bull. 4: 1–12.

Squires, R. L. 1980. A new species of brachyuran from the Paleocene of California. Jour. Paleontol. 54:472–476.

Squires, R. L. 1983. New mollusks from the lower middle Eocene Llajas Formation, southern California. Jour. Paleontol. 57:354–362.

Squires, R. L. 1984. Megapaleontology of the Eocene Llajas Formation, Simi Valley, California. Natur. Hist. Mus. Los Angeles Co., Contrib. Sci. No. 350. 76 pp.

Squires, R. L. & R. Demetrion. 1990. New early Eocene marine gastropods from Baja California Sur, Mexico. Jour. Paleontol. 64:41–46.

Toulmin, L. D. 1977. Stratigraphic distribution of Paleocene and Eocene fossils in the eastern Gulf Coast region. Geol. Surv. Alabama, Monograph 13, Vol. 1, 602 pp.

Wenz, W. 1938–1941. Gastropoda. Allgemeiner Teil und Prosobranchia. Pp. 1–1639. *In:* O. H. Schindewolf (ed.), Handbuch der Paläozoologie. Gebrüder Borntraeger: Berlin.

Zinsmeister, W. J. 1983. Late Paleocene ("Martinez Provincial Stage") molluscan fauna from the Simi Hills, Ventura County, California. Pp. 61–70. *In:* R. L. Squires & M. V. Filewicz (eds.), Cenozoic geology of the Simi Valley area, southern California. Pacific Sec., Soc. Econ. Paleontol. & Mineral.: Los Angeles, California.

The Veliger 33(3):293–298 (July 2, 1990)

THE VELIGER

Tibiaporrhais, a New Late Cretaceous Genus of Aporrhaidae Resembling *Tibia* Röding

by

WILLIAM P. ELDER

U.S. Geological Survey, Mail Stop 915, 345 Middlefield Road,
Menlo Park, California 94025, USA

Abstract. Newly discovered late Campanian specimens of the gastropod ?*Nudivagus cooperensis* Stephenson, 1941, reveal a spined outer lip characteristic of the Aporrhaidae. This feature necessitates removal of this species from the Cerithiidae and placement in a new genus, ***Tibiaporrhais,*** of the Aporrhaidae. The type species of *Nudivagus, N. simplicus* Wade, 1917, lacks evidence of an aporrhaid aperture and is retained in the Cerithiidae because of this and other differences in shell morphology that separate it from ?*Nudivagus cooperensis*. Unfortunately, a complete aperture for the type species of *Nudivagus* is unknown; *Nudivagus* therefore cannot be absolutely precluded from the Aporrhaidae.

Tibia japonica (Nagao, 1932), from the Campanian of Soviet Sakhalin, also is placed in ***Tibiaporrhais*** gen. nov., as is a similar undescribed species from the Campanian of California. Similarities in shell morphology between ***Tibiaporrhais*** and *Tibia* Röding, 1798, suggest either a relatively close evolutionary relationship between the genera, implying that *Tibia* may be more closely allied to the Aporrhaidae than to the Strombidae, or that the genera are homeomorphic. Anatomical research is needed in order to assess these possibilities.

INTRODUCTION

The classification of fossil gastropods lacking ornament is often a difficult and confusing task, especially when the easily damaged apertures are usually incomplete. This problem is especially evident in the case of the Late Cretaceous ?*Nudivagus cooperensis,* which was known for over 40 yr before newly discovered specimens with nearly complete apertures indicated the need for placement in a new genus of the Aporrhaidae.

This paper will name and document ***Tibiaporrhais***, the new genus of the Aporrhaidae, and further describe and illustrate ***Tibiaporrhais*** *cooperensis* (Stephenson, 1941), the type species. In addition to this late Campanian to early Maastrichtian species of the Western Interior and Gulf Coast of North America, two Campanian north Pacific species, *Tibia japonica* (Nagao, 1932) and a newly discovered species from California, will be assigned to ***Tibiaporrhais***. These latter species may provide ancestors to the present day Indo-Pacific *Tibia*.

SYSTEMATIC PALEONTOLOGY

The specimens described or mentioned in this paper have the following repository or locality (loc.) abbreviations: USNM—National Museum of Natural History (formerly United States National Museum); UCM—University of Colorado Museum, Boulder, Colorado; USGS—U.S. Geological Survey; CAS—California Academy of Sciences.

Family Aporrhaidae Mörch, 1852

Genus ***Tibiaporrhais*** Elder, gen. nov.

(Figures 1, 3, 4, 6–9)

Type species: ?*Nudivagus cooperensis* Stephenson, 1941, here designated.

Diagnosis: A large, high spired aporrhaid having (1) subdued sculpture consisting of fine spiral striae and growth lines, and (2) a slightly expanded outer lip with two, moderately long, spinelike processes that arise from indistinct carinae that extend for less than the latter half of the body whorl.

Description: Shell large for family (8 to 10 cm in length); turriculate, having 8 to 11 whorls and spire angle of 20 to 30 degrees. Whorl sides broadly convex anteriorly and slightly constricted posteriorly below a distinct, but closely appressed suture. Surface ornament weak; consisting of numerous crowded, narrow spiral striae and fine, sinuous axial growth lines. Aperture moderately elongate and trap-

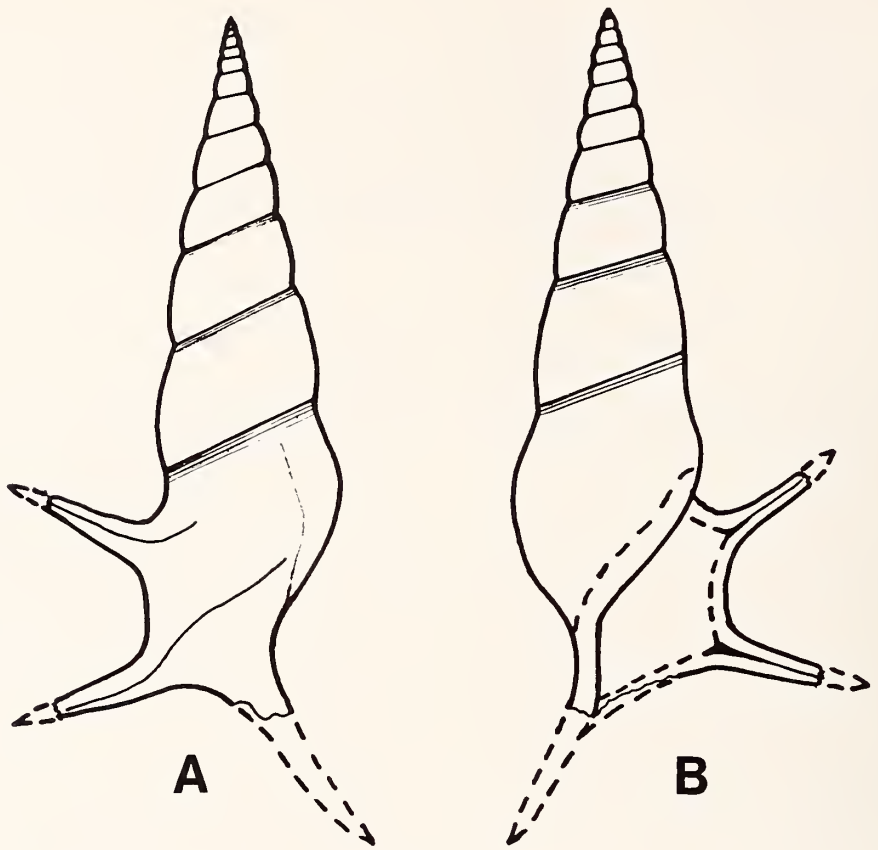


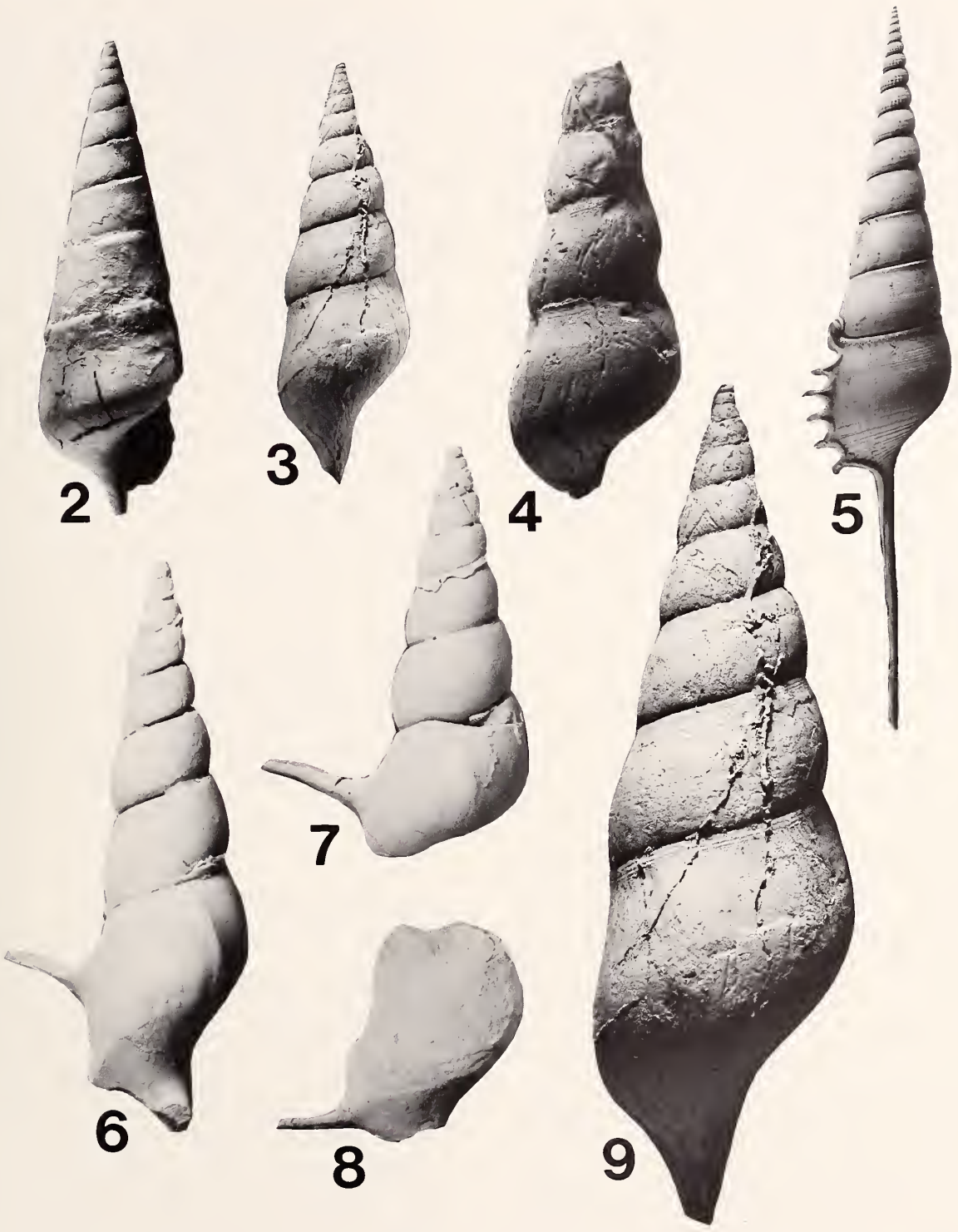
Figure 1

Reconstruction of ***Tibiaporrhais*** *cooperensis* (Stephenson, 1941) based on a composite of three specimens, ×1. A, abapertural view; B, apertural view. Dashed lines denote portions of shell not present on any specimen and therefore subjectively drawn.

ezoidal. Outer lip slightly flaring with two discrete spine-like processes originating from two indistinct carinae that extend for less than one-third of body whorl; posterior process projects in slightly posterior direction, anterior process projects in horizontal to slightly anterior direction. Anterior canal broken on all specimens, but suggestive of moderate length (Figure 1). Inner lip slightly callused. Lacks evidence of posterior canal or callus extending upwards onto spire.

Remarks: This genus is most similar to *Dicroloma* Gabb, 1868, but differs significantly in lacking carinae on the spire. ***Tibiaporrhais*** also is similar to *Lispodesthes* White, 1875, but has a higher spire and lacks secondary callus. The new genus differs significantly from *Aporrhais* DaCosta, 1778, *Tessarolax* Gabb, 1864, and *Helicaulax* Gabb, 1868, in not possessing a posterior canal attached to the spire by callus, and from *Gymnarus* Gabb, 1868, *Pyktes* Popenoe, 1983, and *Tephlon* Popenoe, 1983, by having a higher spire, and by lacking secondary callus and a heavy, bent, posterior projection of the outer lip. ***Tibiaporrhais*** differs from *Anchura* Conrad, 1860, by lacking the broadly flaring outer lip with posteriorly projecting process characteristic of the latter genus. The lack of both a broadly flaring outer lip and prominent surface ornament, as well as the presence of two discrete lateral spines, serve to distinguish ***Tibiaporrhais*** from *Drepanochilus* Meek, 1864, *Arrhoges* Gabb, 1868, and *Graciliala* Sohl, 1960.

Tibiaporrhais apparently includes not only the late Campanian to early Maastrichtian species *?Nudivagus cooperensis,* but also the Campanian species *Tibia japonica* (Nagao, 1932) from Sakhalin. The surface ornament and constriction below the suture are slightly stronger on the latter species than the former (for comparison see NAGAO, 1932:44–45, pl. 7, figs. 1–3, 5, 6; HAYAMI & KASE, 1977: 59, pl. 7, fig. 4), but their overall shape, size, and ornamentation are very similar. The apertures of all *Tibia japonica* specimens are imperfect, but NAGAO (1932) states that the thin outer lip bears two processes of unknown length that originate from relatively indistinct carinae on the body whorl (see NAGAO, 1932:pl. 7, fig. 3b). In addition, a specimen from Campanian strata in the Sacramento Valley of California (Figure 4) bears strong resem-



Explanation of Figures 2 to 9

Figure 2. *Nudivagus simplicus* Wade, 1917; Holotype, USNM 32938, ×1. Figure 3. ***Tibiaporrhais*** *cooperensis* (Stephenson, 1941); UCM 30670, latex peel of external mold, ×1. Figure 4. ***Tibiaporrhais*** sp.; USNM 442113, ×1. Figure 5. *Tibia fusus* Linné, 1758; CAS 66959, ×0.5. Figures 6–9. ***Tibiaporrhais*** *cooperensis* (Stephenson, 1941); UCM 30670. Figures 6, 7. Internal molds with posterior spinelike process intact, ×1. Figure 8. Internal mold with anterior spinelike process intact, ×1. Figure 9. Latex peel of external mold showing fine ornamentation of shell-surface, ×2.

blance to ***Tibiaporrhais*** *japonica* (Nagao, 1932) and also is tentatively placed in ***Tibiaporrhais***, despite its broken aperture that shows no evidence of spinelike processes. Features of this specimen are discussed below.

Nudivagus Wade, 1917, is not reassigned to the Aporrhaidae because evidence for an expanded aperture and apertural spines is lacking in the type species, *Nudivagus simplicus* (Figure 2). In addition, this species has a narrow, tabulate shoulder, flatter whorl sides, and sharper angulation from the anterior to peripheral sides of the body whorl relative to ***Tibiaporrhais*** *cooperensis* (Figure 3) (for comparison see Wade, 1917, 1926; Stephenson, 1941; Sohl, 1960). The shape of the growth lines and the spiral striae constituting the surface ornament of the two species are very similar, however, and incomplete apertures on all specimens of *Nudivagus simplicus* do not absolutely preclude this species from being congeneric with ***T.*** *cooperensis*.

Occurrence: ***Tibiaporrhais*** is known from strata of late Campanian and early Maastrichtian age in the Western Interior and Gulf Coast regions of the United States, respectively. It is also found in Campanian age strata of the eastern North Pacific in central California and of the western North Pacific in Soviet Sakhalin.

Etymology: ***Tibiaporrhais***—A *Tibia*-like aporrhaid.

Tibiaporrhais *cooperensis* (Stephenson, 1941)

(Figures 1, 3, 6–9)

?*Nudivagus cooperensis* Stephenson, 1941:294–295, pl. 54, figs. 11, 12; Sohl, 1960:79; Wolfe & Kirkland, 1986: 207.

Material: Holotype—USNM 76900, USGS collection 14063: one moderately well-preserved specimen with broken aperture and anterior canal. Hypotypes—UCM 30670, loc. 81007: two internal molds with posterior processes preserved and broken anterior canals, one internal mold of body whorl with anterior process preserved, and one well-preserved external mold without aperture or anterior canal.

Description: Shell thin, large, turriculate (preserved portions of adult specimens 75 to 90 mm in height), with 10 to 11 whorls and spiral angle of about 30 degrees (Figures 3, 6). Whorl sides broadly convex and slightly constricted anterior of closely appressed suture. Surface ornament consisting of weak spiral striae and axial growth lines (Figure 9). Spiral striae and interspaces broader and more distinct immediately anterior of suture, becoming narrower, less distinct, and finally disappearing on anterior half of whorls. Sinuous growth lines slightly prosocline below suture, increasing in angle on upper half of whorl, and arching over whorl periphery. Slightly prosocline poorly defined swelling developed one-third revolution back from aperture on external surface of body whorl; swelling well developed on internal mold and accompanied by a slight abapertural constriction. Ventral periphery of body whorl broadly rounded. Two indistinct carinae present on body whorl behind spinelike lateral labral processes; anterior carinae sinuous at base of process, extending back to vertical swelling; posterior carinae posteriorly bending at base of spine, extending back less than one-quarter revolution (Figure 7). Anterodorsal margin of body whorl sharply constricted between anterior carinae and anterior canal. Length and shape of anterior canal uncertain; available material suggesting a moderately long, ventrally bending, spinelike process (Figure 1). Aperture moderately elongate and trapezoidal, but poorly defined from existing material. Outer lip slightly flaring with two 15 to 18 mm long spinelike processes; posterior spine projecting in posterior direction (ca. 70 degrees from axis of spire) (Figures 6, 7), anterior spine projecting in horizontal to slightly anterior direction (Figure 8). Inner lip slightly callused. Lacks evidence of posterior canal or callus extending upwards onto spire.

Remarks: ***Tibiaporrhais*** *cooperensis* differs from ***Tibiaporrhais*** *japonica* (Nagao, 1932) and ***Tibiaporrhais*** sp. (Figure 4) by having a greater apical angle (ca. 30 degrees versus 20 degrees), greater number of whorls (ca. 11 versus 8), finer and less prominent spiral striae, and less well-developed constriction of the whorl periphery below the suture.

Occurrence: Holotype from the lower Maastrichtian (*Exogyra cancellata* zone) Navarro Group, Neylandville Marl, near Cooper, Texas. Hypotypes from the upper Campanian (upper *Baculites compressum* to lower *Baculites cuneatus* zones), middle part of the Pierre Shale near Kremmling, Colorado (see Appendix for locality descriptions).

Tibiaporrhais sp.

(Figure 4)

Material: Illustrated specimen—USNM 442113, USGS Mesozoic loc. M4013. One moderately preserved specimen with spire, aperture, and anterior canal broken.

Remarks: This specimen strongly resembles ***Tibiaporrhais*** *japonica* in having a spire with ca. 8 whorls and an apical angle of ca. 20 degrees, and in being more constricted between the suture and whorl periphery than is ***T.*** *cooperensis* (compare with Nagao, 1932:pl. 7, figs. 1, 2; Hayami & Kase, 1977:pl. 7, fig. 4). However, the lower whorl periphery is more rounded anteriorly than on ***T.*** *japonica*, more closely resembling ***T.*** *cooperensis* in this respect. The spiral striae and axial growth lines of ***Tibiaporrhais*** sp. appear to be intermediate in strength between those of ***T.*** *japonica* and ***T.*** *cooperensis*, although the worn nature of the shell surface makes this observation somewhat suspect. Overall characteristics of this specimen suggest that it belongs to a species closely allied to ***T.*** *japonica* and somewhat intermediate in character between that species and ***T.*** *cooperensis*; however, better material is needed before this apparently new species can be adequately described.